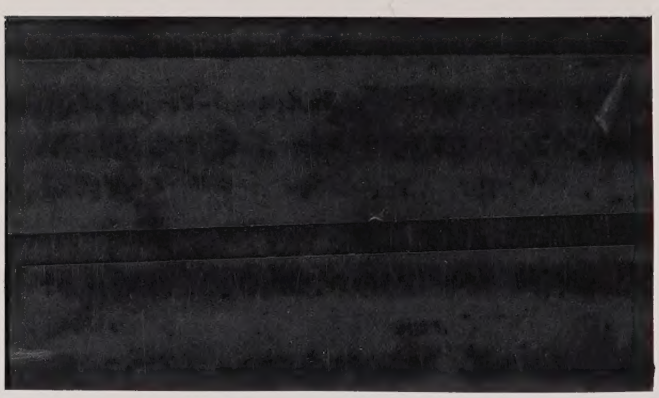
E-H RESEARCH LABORATORIES, INC.
163 ADELINE STREET · OAKLAND, CALIFORNIA 94607



MODEL 133A
PULSE GENERATOR

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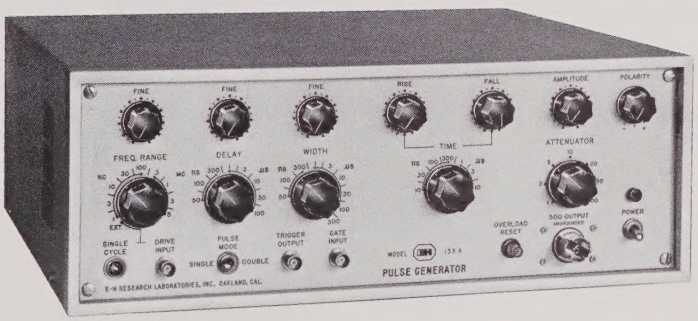
PULSE GENERATOR



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Issued 2-15-66

SECTION 1
CHARACTERISTICS

1-1 GENERAL

The E-H Model 133A is a solid state pulse generator that has a broad range of output pulse parameters and operating features. The Model 133A will provide up to one ampere into a 50-ohm load within 10 nanoseconds. Depending on pulse width, it will provide rising and falling ramps up to 10 microseconds. Pulse width is variable up to 300 microseconds, and pulse repetition rate is variable from 1 kilohertz to 5 megahertz. There are separate trigger input and output provisions for synchronization with other instruments, and externally-driven gate circuit for gated pulse burst operation.

The single cycle feature provides individual pulses each time a pushbutton switch is depressed. The output terminal is ungrounded for operation with the E-H Model 910 Current Sources. The current sources permit mixing high speed pulses or driving inductive loads.

The Model 133A also has an optional remote amplitude control feature which operates in conjunction with the E-H Model 930 Digital to Analog Converter. With the remote control feature, the output pulse amplitude of the Model 133A may be varied over a 2.5:1 ratio in any individual attenuation range.

1-2 SPECIFICATIONS

PULSE REPETITION FREQUENCY: 1 kilohertz to 5 megahertz from internal clock. Zero to 5 megahertz from external clock. Repetition rate is continuously variable from 1 kilohertz to 5 megahertz by coarse selector (1/3/10/30/100 kilohertz, 0.3/1/3/5 megahertz), and a vernier control.

OUTPUT PULSE AMPLITUDE: Positive or negative 200 millivolts to 50 volts, continuously variable, with step ATTENUATOR and variable AMPLITUDE control. Attenuation ranges are 1/2/5/10/20/50/100.

RISETIME (10% to 90%): 10 nanoseconds to 10 microseconds, continuously variable by coarse (TIME) selector switch (10/30/100/300 nanoseconds, 1/3/10 microseconds), and individual vernier (RISE) control.

FALLTIME (10% to 90%): 20 nanoseconds to 10 microseconds, continuously variable by coarse (TIME) selector switch and vernier (FALL) control.

PULSE WIDTH: 50 nanoseconds to 300 microseconds, continuously variable by coarse (WIDTH) selector switch (50/100/300 nanoseconds, 1/3/10/30/100/300 microseconds) and (FINE) vernier control.

PULSE DELAY: 75 nanoseconds to 100 microseconds, continuously variable by coarse (DELAY) selector switch (75/100/300 nanoseconds, 1/3/10/30/100 microseconds) and (FINE) vernier control.

JITTER: Less than 0.1% +50 picoseconds. Includes repetition rate, width and delay jitter.

OUTPUT TERMINATING IMPEDANCE: 50 ohms. The Model 133A operates as a voltage source for both polarities. The output is protected against accidental overload by an automatic protection circuit which incorporates a combination overload indicator light and reset pushbutton switch.

DUTY FACTOR: Greater than 50%.

WAVEFORM DISTORTION: Positive pulses less than 3% peak-to-peak. Negative pulses less than 3% peak-to-peak.

EXTERNAL DRIVE: +1.5 volts minimum to +15 volts maximum. The Model 133A may be externally driven from zero to 5 megahertz. Maximum risetime for external drive pulse is 0.1 microsecond/volt. $Z_{in} \cong$ 200 ohms.

TRIGGER OUTPUT: +1.5 volts into 50 ohms, +3 volts into open circuit. Risetime approximately 5 nanoseconds/volts. $Z_{out} \cong 50$ ohms.

SYNCHRONOUS GATE: -2 volt minimum to -15 volt maximum required to block output pulse train. The termination of each gating signal initiates the pulse train, thus synchronizing the output pulse with the gate signal. $Z_{in} \cong 300$ ohms.

DOUBLE PULSE: A front-panel switch provides either single or double pulse operation. In double pulse mode, maximum repetition rate is 2.5 megahertz for 5 megahertz double pulse rate. Minimum spacing is 30% of pulse width; spacing is determined by the DELAY control. Pulses are indentical in amplitude, width, and polarity.

SINGLE CYCLE OPERATION: A front-panel pushbutton provides single cycle operation when depressed by the operator.

DIGITAL TO ANALOG CONTROL: A built-in socket is provided for the Model 930 Digital to Analog plug-in circuit board, permitting optional remote control of output-pulse amplitude.

DIMENSIONS

Cabinet-mount:	6" high; 17" wide; 14" deep
Rack-mount:	7" high; 19" wide; 14-1/4" deep; 15-3/4" over-all.
Weight:	31 lbs net; 44 lbs packed; 55 lbs packed for export.

POWER REQUIREMENTS: 105/125 volts, 50/60 hertz, 180 volt-amperes (230 volt service available at no extra cost).

1-3 ACCESSORIES

The E-H Model 133A is compatible with the E-H GR series accessories and other instruments with GR (General Radio) 874 connectors. For further accessory information, refer to the data at the back of this manual.

SECTION 2
OPERATING INFORMATION

2-1 UNPACKING

Immediately after unpacking the instrument, carefully inspect and evaluate the condition of the shipping container and instrument for evidence of damage that might have occurred during shipment or handling. If damage is noted, the responsible carrier or agency should be promptly notified.

2-2 234 VOLT OPERATION

The internal power supply of the E-H Model 133A is normally wired for 117 vac operation. For 234 volt operation, reconnect the transformer primary. Refer to the power supply schematic for the proper connections.

2-3 OUTPUT IMPEDANCE

The Model 133A is designed to operate into a 50-ohm resistive load. Operation into any other impedance will cause some pulse distortion. Loads with appreciable capacitive or inductive components will have a marked effect on the leading and trailing edges of the pulse.

Use the E-H Model 975 Sequential Transformer to match the Model 133A output to 1-ohm loads. For additional accessory information refer to the E-H Pulse Accessory information in back of this manual.

2-4 CABLES, CONNECTORS AND ATTENUATORS

At the minimum risetime (10 nanoseconds) of the Model 133A, the pulse has frequency components up to 100 megahertz. If any of these high frequency components are attenuated by connectors, cables or attenuators that do not have a flat frequency response in excess of 100 megahertz, degradation of the pulse risetime will result. Mismatch effects can also degrade the pulse waveform; consequently, consideration and care must be taken to preserve the quality of the pulse output when coupling it to the system or device under test.

Some of the precautions to observe are:

a. Always terminate the output of the Model 133A in a 50-ohm resistive load.

b. If the input impedance of the device or system under test is other than 50 ohms, use an impedance matching device so that mismatch effects will not degrade the pulse waveform.

c. Make sure that all connectors, attenuators, and cables are of proper impedance and have a flat frequency response in excess of 100 megahertz. Use only high-quality 50-ohm coaxial cable, such as RG-213/U. RG-8A/U is not recommended because the production tolerances are too broad for precision pulse work, and can result in mismatches. RG-213/U is manufactured to closer tolerances. Similarly, for RG-9/U, use RG-214/U. For best results, use short cables, since long cables tend to attenuate the high frequency components of the pulse. General Radio (GR) 874 series coaxial connectors are required at the 50 Ω OUTPUT connector of the Model 133A. All other front panel connectors are BNC.

2-5 OPERATING CONTROLS AND CONNECTORS

Table 2-1 contains a list of operating controls along with the function of each.

2-6 OPERATING NOTES

a. GATE INPUT OPERATION. The gate circuit disables the clock circuit for the duration of the gate input signal. If the gate signal is repetitive, the output signal of the Model 133A will be a series of pulse bursts. The bursts are separated in time by the gate pulse width. The duration of each burst is determined by the time the gate signal is off. The frequency of the pulse bursts is determined by the gate pulse period.

For example, suppose the desired pulse burst is to recur every 100 microseconds; there are to be 5 pulses in each burst and each pulse in the burst is to recur every 10 microseconds. For these conditions, adjust the gate pulse generator for a 10 kilohertz repetition rate (gate pulse period = 100 microseconds). For 5 pulses in each burst, the clock multivibrator should remain on longer than 40 microseconds, but less than 50 microseconds. Therefore, the gate pulse width should be somewhat greater than 50 microseconds, but less than 60 microseconds (gate pulse duty factor ≅ 50%). For 10 microseconds pulse repetition period on the Model 133A, adjust the internal clock to 100 kilohertz (pulse period = 10 microseconds).

TABLE 2-1 OPERATING CONTROLS AND CONNECTORS

ITEM	FUNCTION
POWER	With the line cord connected to a 117 vac 50/60 hertz power source, and the POWER switch at the ON position, the fan will start and the POWER indicator will light.
FREQ. RANGE	Selects pulse repetition rate as determined by either the internal clock or an external drive input pulse. Pulse repetition ranges are: 1/3/10/30/100 kilohertz; .3/1/3/5 megahertz; or external drive from zero to 5 megahertz.
FINE (FREQ. RANGE)	Continuously variable; adjusts pulse repetition rate in each range with overlap to adjacent ranges.
DELAY	Selects time delay between TRIGGER OUTPUT pulse and 50 Ω OUTPUT pulse. Delay-time ranges are: 75/100/300 nanoseconds; 1/3/10/30/100 microseconds.
FINE (DELAY)	Continuously variable; adjusts pulse delay time in each range with overlap to adjacent ranges.
WIDTH	Selects the output pulse width. Pulse width ranges are: 50/100/300 nanoseconds; 1/3/10/30/100/300 microseconds.
FINE (WIDTH)	Continuously variable; adjusts output pulse width time in each range with overlap to adjacent ranges.
TIME	Selects output pulse risetime and falltime (voltage ramp) ranges from 10 nanoseconds to 10 microseconds. Risetime ranges are 10/30/100/300 nanoseconds; 1/3/10 microseconds. Within each range, rise and fall times are individually and continuously adjustable with the RISE and FALL controls.
RISE (TIME)	Continuously variable; adjusts output pulse risetime (voltage ramp) in each TIME range, with overlap to adjacent ranges.
FALL (TIME)	Continuously variable; adjusts output pulse falltime (voltage ramp) in each TIME range, with overlap to adjacent ranges.
AMPLITUDE	Continuously variable; adjusts 50 Ω OUTPUT pulse amplitude from ±200 millivolts to ±50 volts, in conjunction with the ATTENUATOR selector switch.
ATTENUATOR	Provides 7 resistive step attenuation ratios. When 50 Ω OUTPUT connector is terminated with a 50-ohm resistive load, attenuation ratios are 1:1, 2:1, 5:1, 10:1, 20:1, 50:1, and 100:1. The ATTENUATOR, in conjunction with the AMPLITUDE control, provides continuous pulse amplitude control from ±200 millivolts to ± 50 volts.
POLARITY	Selects one of two output pulse polarities: positive or negative.

TABLE 2-1 OPERATING CONTROLS AND CONNECTORS

(CONTINUED)

ITEM	FUNCTION
PULSE MODE (TOGGLE SWITCH)	When the PULSE MODE toggle switch is set to the SINGLE position, there is one output pulse during the pulse repetition period; the output pulse follows the trigger pulse by the delay time. When set to the DOUBLE position, there are two output pulses during the pulse repetition period; the first output pulse is approximately coincident with the trigger pulse and the second output pulse occurs later, as determined by the delay time. For optimum operation, the delay time should be approximately 30 per cent greater than the output-pulse width, but less than approximately 75 per cent of the output pulse repetition period.
SINGLE CYCLE	With the FREQ. RANGE selector switch set to EXT. and with no external-drive signal applied to the instrument, the SINGLE CYCLE pushbutton switch initiates a single output-pulse each time it is depressed. The SINGLE CYCLE switch provides one-time triggering action.
OVERLOAD RESET	OVERLOAD RESET light turns on whenever output current exceeds 1 ampere. To restore to proper operation, correct the overload condition and depress the combination OVERLOAD RESET switch and indicator light.
50 Ω OUTPUT CONNECTOR (GR 874 Connector)	Provides 1 ampere maximum output pulse to a 50-ohm load. For best results, use a 50-ohm resistive load and 50-ohm coaxial cable, such as RG-213/U. The Model 133A appears to the load as a voltage source in either polarity. The 50 Ω OUTPUT connector is not grounded to the chassis. For further discussion, see Section 2-6d.
TRIGGER OUTPUT CONNECTOR (BNC)	Provides a positive 1.5 volt pulse into 50 ohms, 3 volts open circuit. The trigger pulse is approximately 20 nanoseconds wide, and its risetime is approximately 5 nanoseconds per volt. $Z_{out} \cong 50$ ohms.
GATE INPUT CONNECTOR (BNC)	A negative dc voltage level or pulse at this connector inhibits the output pulse train. The gate signal should be -2 volts minimum to -15 volts maximum. The termination of each gate signal initiates the pulse train, thus synchronizing the output pulse with the gate signal. $Z_{in} \cong 300$ ohms.
DRIVE INPUT CONNECTOR (BNC)	Permits an externally supplied pulse train with an amplitude from +1.5 volts minimum to +15 volts maximum at a repetition rate from zero to 5 megahertz to drive the Model 133A. Maximum external input pulse risetime should be less than 0.1 microsecond per volt. External drive input impedance is approximately 200 ohms.

b. RAMP RATE OPERATION. As the ramp rate is increased, increase the pulse width and decrease the repetition rate, as necessary. Pulse width should be greater than approximately twice the ramp rate or the output pulse amplitude and waveform tend to degenerate.

c. REMOTE AMPLITUDE CONTROL WITH E-H MODEL 930 D to A CONVERTERS. The D to A Converter operates as a three-decade, binary-coded, analog control circuit. It functions as a remote output pulse amplitude control for the Model 133A Pulse Generator.

There are three sets of four parallel input lines. In each set, the lines are in 1, 2, 4, 8 binary-coded sequence. The entire group of 12 input lines therefore permit a 3-decade binary input count. The converter output is variable, depending upon the digital input count, where the input to each line is either zero or +10 volts.

The converter acts as a current source; the output current varies from zero to 10 millamperes in 10 microampere increments. The output current drives the base of Q2 in the Model 133A power supply control amplifier. By changing the amplifier input current, the converter circuit controls the power supply output voltage, and subsequently, the output pulse amplitude.

The D to A Converter circuit is composed of a parallel combination of 12 individual switch circuits--one for each input line. Each circuit is roughly equivalent to a resistor and switch is series (See Figure 2-1). The converter output current is the sum of the currents through the closed switch circuits. The reset circuit operates by effectively causing all switches to open simultaneously.

Remote Amplitude Control Operation:

(1) Remove the E-H Model 133A cover and insert the D to A converter circuit board in its socket. The circuit board should fit such that the circuit components are facing the front panel, as viewed from the front of the instrument.

(2) Wire an Amphenol mating connector (Part Number 57-30240) to fit the female rear panel connector on the Model 133A. The proper pin connections are indicated in Table 2-2. Each line except V_O and +10 volts should be connected to one side of a normally open switch (a pushbutton switch is convenient). Both V_O and the +10 volt line voltage are supplied by the Model 133A. No external power supplies are required.

(3) Connect the +10 volt line to the other side of each switch.

(4) Turn the Model 133A POWER switch ON.

(5) Turn the ATTENUATOR switch to 1 (fully counterclockwise).

(6) Observe the pulse output on the calibrated vertical channel of an oscilloscope. Adjust the AMPLITUDE control so that the output pulse amplitude is 20 volts, as measured on the oscilloscope. Be sure D to A Converter output is zero. (To set the CONVERTER output to zero, close the reset switch momentarily.) If necessary, adjust the Model 930 zero trimming potentiometer for zero output.

(7) Turn on the appropriate D to A Converter circuits for a count of 300. Adjust the multiturn trimming potentiometer on the D to A Converter circuit board so that the output pulse amplitude is 50 volts, as measured on the oscilloscope.

(8) For remote control operation, momentarily close any combination of the switches for a total count of 300 or less. The output pulse amplitude should respond in the ratio of 10 volts per 100 count. To reduce the output pulse to minimum (20 volts), close the reset switch. For output pulse amplitude less than 20 volts, use the ATTENUATOR.

(9) Do not use a count greater than 300, since the Model 133A will overload. To restore the Model 133A to normal operation, reset the Model 930 D to A Converter circuits and depress the OVERLOAD RESET switch.

(10) In normal operation, minimum output amplitude (with the ATTENUATOR control set to 1) is approximately 20 volts. It is also possible to modify the Model 133A for remote programming between zero and 50 volts. For information, consult the factory, or the E-H publication entitled "Model 930 Digital to Analog Converter".

d. UNGROUNDED 50 Ω OUTPUT CONNECTOR. The 50 Ω OUTPUT Connector of the Model 133A floats with respect to ground. For normal use, there are no special operating precautions.

If the pulse system requires several pulse generators for pulse mixing, or to operate in parallel; or the system requirement calls for driving a low-impedance reactive load; or for a low-output capacity current-source, then the ungrounded 50 Ω OUTPUT of the Model 133A may be operated with the E-H Model 910 Current Sources. The Current Sources are high-output impedance devices which are useful for pulse mixing or driving low-impedance reactive loads from standard 50-ohm systems.

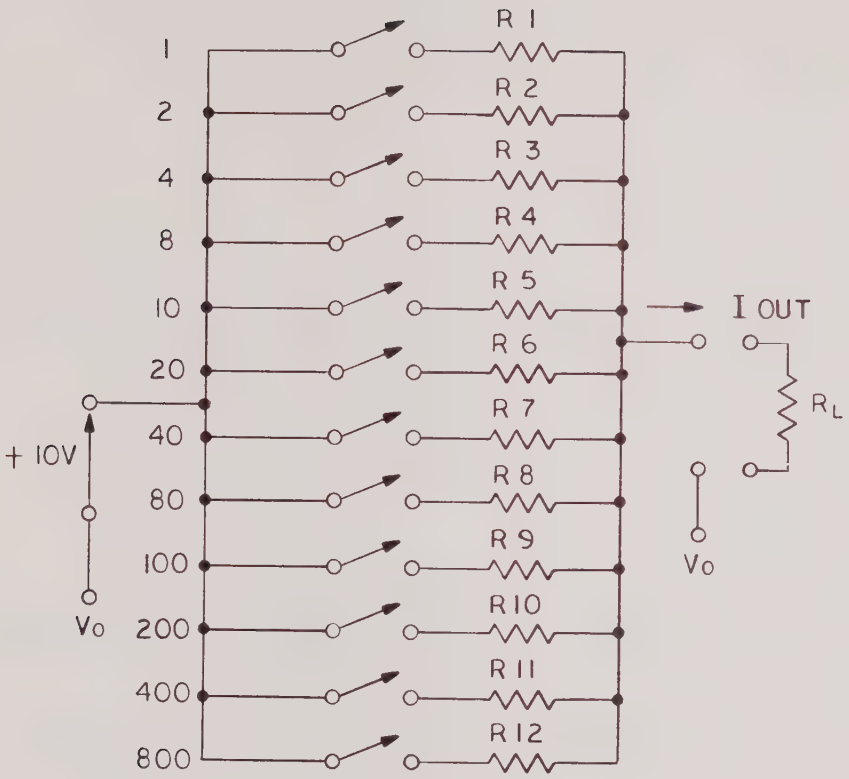


Figure 2-1
D-A Converter Equivalent Circuit

Amphenol Connector Pin Number	1	2	3	4	5	6	7	8
Line (Count) (or) (Function)	800	400	200	100	80	40	20	10

Amphenol Connector Pin Number	9	10	11	12	13	14	15
Line (Count) (or) (Function)	8	4	2	1	V_o	Re-set	+10v

Table 2-2
D-A Converter Rear Panel Connections

SECTION 3
PARTS LIST

3-1 ORDERING INFORMATION

Replacement parts may be ordered through your E-H Representative or from the factory. To be certain that you receive the proper replacement parts, always include the following information with your order:

a. Model Number and Serial Number of the instrument on which the replacement parts will be installed.

b. Circuit or Drawing Reference for which each part is intended.

c. E-H Part Number.

This instrument contains several factory-selected components to ensure optimum performance. In no case should a diode or transistor be replaced with one from a different manufacturer, unless it is on the specific recommendation of E-H.

When replacement parts are necessary, be sure to order through the E-H Customer Service organization. In this way, we can best serve you by providing up-to-date factory recommended parts and service information.

3-2 WARRANTY

This instrument is guaranteed to be free from defects in material and workmanship. Our obligation is limited to repairing the instrument should it prove to be defective, upon our examination, within one (1) year after the purchase date. Fuses and batteries are specifically excluded from warranty. Electron tubes, transistors, and diodes are warranted for six (6) months.

For In-Warranty repair of this instrument, contact E-H Research Laboratories, Inc., Customer Service Department, and provide:

a. Instrument Model Number and Serial Number.

b. Full details concerning the nature of the malfunction.

Shipping instructions, or repair information and parts, will be sent to you promptly.

CUSTOMER SERVICE DEPARTMENT, E-H RESEARCH LABORATORIES, INC.

163 ADELINE STREET, OAKLAND, CALIFORNIA - Phone: TE 4-3030, Area Code 415

CIRCUIT REFERENCE	DESCRIPTION	E-H PART NO.
3-3 TIMING CIRCUIT BOARD		
C2	Cap., 20pf/1kv	311-002
C6, 9	Cap., 20pf/1kv	311-005
C12	Cap., 30pf/1kv	311-006
C3, 5, 7, 10, 11, 13, 16, 17	Cap., .001mfd/1kv	311-010
C1, 14, 15	Cap., .01mfd/600v	311-012
C4	Cap., .1μf/75v	311-014
C18	Cap., 400pf	311-026
C8	Cap., 25μf/25v	316-028
L1	Choke, 1.5μf, 10%	335-001
L2-5	Choke, .68μf, 20%	335-013
CR9 & 13, 18 & 22, 33 & 37	Diode, 1N753A, (matched pairs)	11730
CR19 & 21, 31 & 32, 34 & 36, 39 & 40	Diode, 1N752 (matched pairs)	11731
CR1, 2, 5-8, 10-12, 15-17, 39, 19-21, 31-32, 34-36	Diode, CGD1419	11742
CR14, 23	Diode, 1N751A	374-022
CR38	Diode, 1N746A	374-017
CR24-28	Diode, 1N914B	376-022
CR29	Diode, 40065-RCA	376-044
CR30	Diode, 1N270	376-031
R22	Pot., 2K, 1/2W	551-023
	Tie Point	484-018
R2	Pot., EZ Trim	551-024
	Socket, Transistor	490-002
R31, 52	Resistor, 51Ω, 1/4W, 5%	595-510
R11, 18, 27	Resistor, 100Ω, 1/4W, 5%	595-101
R21, 22, 45, 51, 54, 57	Resistor, 200Ω, 1/4W, 5%	595-201
R6, 7, 40, 43, 44	Resistor, 220Ω, 1/4W, 5%	595-221
R3	Resistor, 240Ω, 1/4W, 5%	595-241
R10	Resistor, 330Ω, 1/4W, 5%	595-331
R13, 47	Resistor, 750Ω, 1/4W, 5%	595-751
R1, 25, 34, 38, 59	Resistor, 1K, 1/4W, 5%	595-102
R16, 48	Resistor, 1.2K, 1/4W, 5%	595-122
R5, 8, 19, 28	Resistor, 1.5K, 1/4W, 5%	595-152
R35	Resistor, 1.8K, 1/4W, 5%	595-182
R9, 14, 41, 46, 53, 55, 58	Resistor, 2K, 1/4W, 5%	595-202
R15, 23, 24, 30, 42, 49, 56	Resistor, 3K, 1/4W, 5%	595-302
R4	Resistor, 10K, 1/4W, 5%	595-103
R37	Resistor, 15K, 1/4W, 5%	595-153
R36	Resistor, 100K, 1/4W, 5%	595-104
R20, 29	Resistor, 330Ω, 1/2W, 5%	596-331
R17, 26	Resistor, 560Ω, 1/2W, 5%	596-561
R39	Resistor, 1K, 1/2W, 5%	596-102
R33	Resistor, 1.2K, 1/2W, 5%	596-122
R32	Resistor, 1.6K, 1/2W, 5%	596-162
R56	Resistor, 220Ω, 1W, 5%	597-221
R60	Resistor, 22M, 1/4W, 5%	595-226
Q1-4, 10	Transistor, 2N706B	663-023
Q5-9, 11-17	Transistor, 2N966	663-032
Q18	Transistor, CDQ10239	11701
3-4 OUTPUT CIRCUIT BOARD		
PHASE I ASSEMBLY		
C11	Cap., 10pf	311-001
C17	Cap., 20pf	311-002
C9	Cap., 250pf	311-004
C3, 4	Cap., 100pf	311-007
C5, 6	Cap., .001μf	311-010
C1, 8, 10, 13, 14, 16, 19, 26, 28, 29	Cap., .01μf	311-012
C30	Cap., 2.2μf	311-019
C20, 25	Cap., 10μf/100v	316-032
C2, 27	Cap., 5μf/12v	316-043
C7	Cap., 10μf/10v	316-046
C18	Cap., 8-50pf	333-007
L2	Choke, 1.5μh	335-001
L1	Choke, .68μh	335-013
L5	Choke, 1.5μh	335-018
CR25, 26	Diode, 1N746A	374-017
CR5, 6	Diode, 1N751A	374-022
CR1-4, 8, 9, 11, 13, 19, 20, 24, 27, 29-44, 22	Diode, 1N914B	376-022
CR7, 10, 12	Diode, 1N270	376-031
CR14-18, 21, 23	Diode, FD777	376-059
	Socket, Elco	490-002
	Socket, 3-pin Nugent	490-003
	Socket, Nugent EX500	490-021
R17-21, 45	Resistor, 4.7Ω, 1/4W, 5%	595-047
R16, 33-36	Resistor, 5.1Ω, 1/4W, 5%	595-051
R24	Resistor, 33Ω, 1/4W, 5%	595-330

CIRCUIT REFERENCE	DESCRIPTION	E-H PART NO.
R41	Resistor, 24Ω, 1/4W, 5%	595-240
R1, 2, 42	Resistor, 51Ω, 1/4W, 5%	595-510
R5, 9, 43, 44, 55	Resistor, 100Ω, 1/4W, 5%	595-101
R56	Resistor, 200Ω, 1/4W, 5%	595-221
R61	Resistor, 250Ω, 1/4W, 5%	595-241
R15	Resistor, 270Ω, 1/4W, 5%	595-271
R52	Resistor, 300Ω, 1/4W, 5%	595-301
R51	Resistor, 430Ω, 1/4W, 5%	595-431
R38, 39, 49, 63	Resistor, 510Ω, 1/4W, 5%	595-511
R47	Resistor, 620Ω, 1/4W, 5%	595-621
R3, 4, 7, 8, 10, 14	Resistor, 1K, 1/4W, 5%	595-102
R54	Resistor, 2K, 1/4W, 5%	595-202
R37	Resistor, 2.4K, 1/4W, 5%	595-242
R48	Resistor, 2.7K, 1/4W, 5%	595-272
R62	Resistor, 4.7K, 1/4W, 5%	595-472
R28	Resistor, 10K, 1/4W, 5%	595-103
R27	Resistor, 22K, 1/4W, 5%	595-223
R30, 58, 65	Resistor, 100K, 1/4W, 5%	595-104
R31	Resistor, 20Ω, 1/2W, 5%	596-200
R53	Resistor, 24Ω, 1/2W, 5%	596-240
R59, 60	Resistor, 43Ω, 1/2W, 5%	596-430
R12	Resistor, 68Ω, 1/2W, 5%	596-680
R11, 13	Resistor, 150Ω, 1/2W, 5%	596-151
R46	Resistor, 1K, 1/2W, 5%	596-102
R6	Resistor, 200Ω, 1/2W, 5%	596-201
R66	Resistor, 2K, 1W, 5%	597-202
R50	Resistor, 20Ω, 2W, 5%	598-200
R32	Resistor, 130Ω, 2W, 5%	598-131
R29	Resistor, 200Ω, 1/2W, 1%	601-006
R64	Resistor, 50Ω, 3W, 5%	610-068
R40	Resistor, 30Ω, 3W, 5%	610-067
R26	Resistor, 619Ω, 1/4W, m.f. 1%	617-001
R25	Resistor, 1.24Ω, 1/2W, m.f. 1%	618-003
R57	Resistor, 2K, 1/2W, 1%	618-005
R23	Resistor, 1K, 1/2W, m.f. 1%	618-007
R22	Resistor, 316Ω, 1/2W, m.f. 1%	618-008
T1	Transformer Assembly	10657
L6	Choke Assembly	10658
L3, 4	Choke Assembly	10890

PHASE II ASSEMBLY

C12, 15, 21-24	Cap., .005μf	312-002
L201	Choke, .22μh	335-016
	AMP Pin	495-027
Q8, 15	Transistor, CDQ10239	11701
Q6	Transistor, 2N2538	663-003
Q21	Transistor, 2N1039	663-015
Q13, 20	Transistor, 2N1132	663-024
Q1-4, 7	Transistor, 2N966	663-032
Q9, 11, 16, 18	Transistor, 2N2950	663-039
Q17	Transistor, 2N2950	11708
Q5, 10, 12, 14	Transistor, 2N1692	11711
Q19	Transistor, 2N2876	11714
	Heat Sink	11358
	Heat Sink	11359
	Heat Sink Adapter	11360
	Heat Sink	11361

3-5 POWER SUPPLY

POWER SUPPLY CHASSIS

T101	Transformer, Power	10568
XA101, 102	P.C. Con., 18-pin	743-008
Q106, 108, 109	Transistor, 2N250	11705
Q105	Transistor, 2N1022	663-007
C102-105	Cap., 1500μf/50v	316-045
C101	Cap., 1280μf/125v	316-014
XA103	P.C. Con., 22-pin	743-001
	Insulator, El. Cap	330-007

LOW VOLTAGE P.C. BOARD

C1, 2	Cap., 250μf/12v	316-031
C3, 4	Cap., 100μf/25v	316-035
CR4, 5, 7, 8	Diode, 1N752A	374-022
CR3, 6	Diode, 1N270	376-031
CR1, 2	Diode, 1N4005	376-034
R9, 28	Pot., 100 (trim)	551-024
R1, 2, 5, 24	Resistor, 330Ω, 1/2W, 5%	596-331
R29	Resistor, 430Ω, 1/2W, 5%	596-431
R10	Resistor, 470Ω, 1/2W, 5%	596-471
R6-8, 14-16, 20, 21, 26	Resistor, 510Ω, 1/2W, 5%	596-511
R33	Resistor, 620Ω, 1/2W, 5%	596-621
R11, 25, 27, 30, 34, 35	Resistor, 1K, 1/2W, 5%	596-102
R4, 17, 36	Resistor, 3K, 1/2W, 5%	596-302
R3, 22, 23	Resistor, 5.1K, 1/2W, 5%	596-512
R19	Resistor, 2Ω, 5W, 5%	610-018
R18, 37	Resistor, 1K, 1/2W, 1%	618-007
R12, 31	Resistor, 931Ω, 1/2W, 1%	618-009
Q1, 5, 6, 10	Transistor, 2N1303	663-011
Q2-4, 7-9	Transistor, CDQ10239	11701

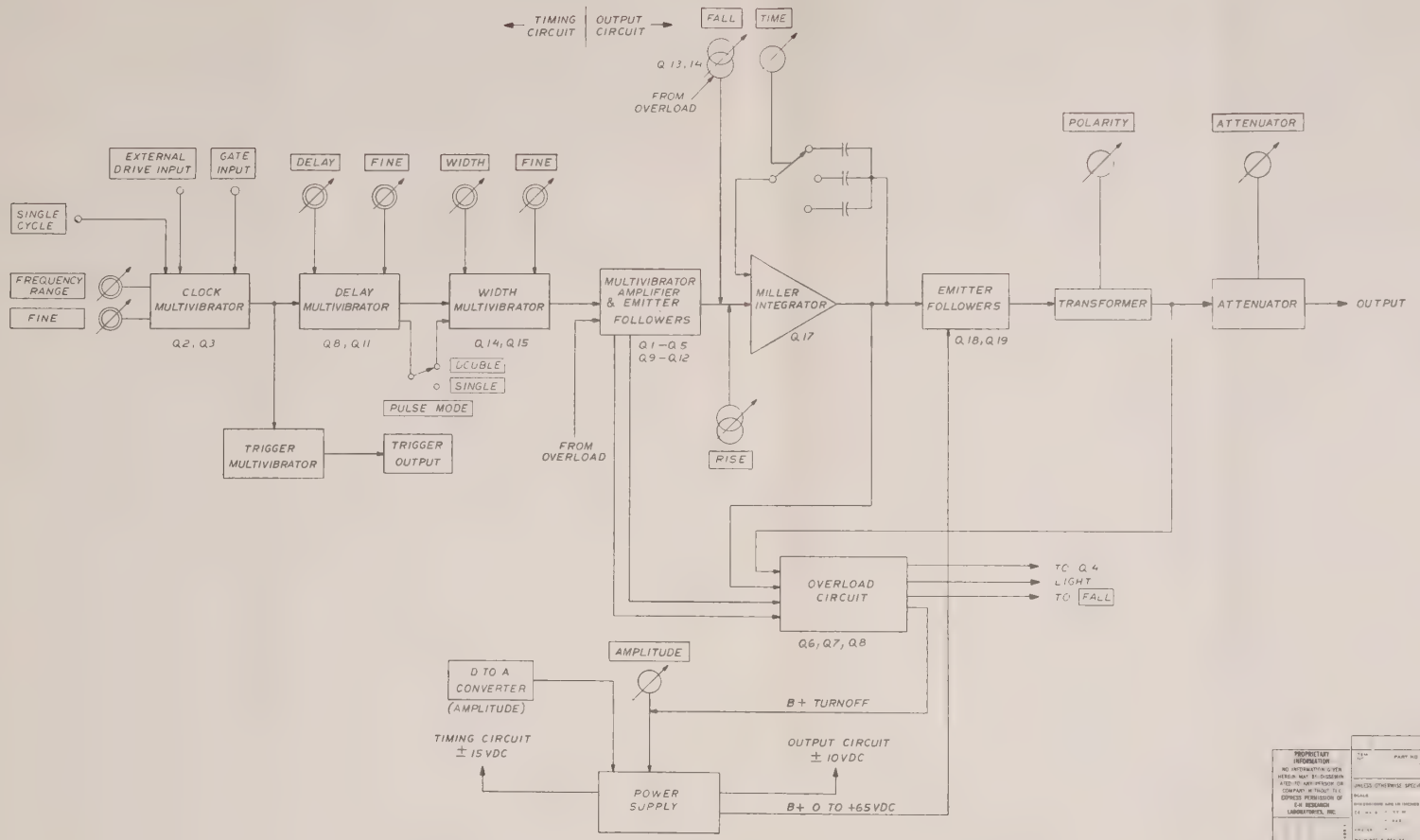
CIRCUIT REFERENCE	DESCRIPTION	E-H PART NO.
HIGH VOLTAGE P.C. BOARD		
C1, 2	Cap., 100μf/150v	316-023
CR5	Diode, 1N746	374-017
CR7	Diode, 1N749	374-044
CR6	Diode, 1N753	374-019
CR1-4	Diode, 1N4005	376-034
R17	Resistor, 100Ω, 1/2W, 5%	596-101
R13	Resistor, 160Ω, 1/2W, 5%	596-161
R12	Resistor, 2K, 1/2W, 5%	596-202
R9	Resistor, 200Ω, 1W, 5%	597-201
R2, 4, 6, 8	Resistor, 51Ω, 1/2W, 5%	596-510
R16	Resistor, 11.5K, 1/2W, 1%	618-012
R21	Resistor, 10K, 2W, 5%	598-103
R20	Resistor, 2Ω, 5W, WW	610-018
R1, 3, 5, 7	Resistor, 10Ω, 3W, WW	610-019
R15	Resistor, 715Ω, 1/2W, 1%	618-010
R10, 11, 14	Resistor, 499Ω, 1/2W, 1%	618-001
R19	Resistor, 1.5K, 3W, WW	610-008
R23	Resistor, 820Ω, 1/2W, 5%	596-821
R22	Resistor, 1.6K, 1.2W, 5%	596-162
FRONT PANEL ASSEMBLY		
DS201	Pilot Light, neon (red)	510-008
R206, 207	Pot., 10-turn, 1K	540-004
R205	Pot., 1K, 2W	550-002
R201, 202, 204	Pot., 5K, 2W	550-003
R213	Resistor, 470Ω, 1/4W, 5%	595-471
R212	Resistor, 100K, 1/2W, 5%	596-104
R211	Resistor, 500Ω, 10W, WW	610-070
S206	Switch, Polarity	624-045
S201, 208	Switch, Toggle DPDT	630-006
S209	Switch P.B. (N.O.)	635-003
S207	Switch P.B. (Short & Ind.)	635-004
J201-203	Connector, UG-1094/U	721-013
	Panel Adapter	739-007
	Insulator, GR	11247
	Ground Shield Angled	11471
J204	Attenuator Assembly	11631
	Switch	11529
FREQ. RANGE SWITCH ASSEMBLY		
S202	Switch	624-042
C210	Cap., 100pf	311-007
C209	Cap., 500pf	311-009
C205	Cap., mylar, .1μf/200v, 5%	320-007
C208	Cap., 1μf/200v, 5%	320-011
C204	Cap., .02μf/200v, 5%	320-022
C207	Cap., .2μf/200v, 5%	320-024
C203	Cap., .033μf/200v, 5%	320-029
C206	Cap., .33μf/200v, 5%	320-030
C211, 212	Cap., 1000pf	326-005
C202	Cap., .01μf/500v, 5%	326-006
C213	Cap., 2500pf/500v, 5%	326-011
C201	Cap., .002μf/500v, 5%	326-012
DELAY SWITCH ASSEMBLY		
S203	Switch, rotary	624-007
C220	Cap., 50pf/500v, 10%	311-006
C218, 219	Cap., 330pf	311-029
C214	Cap., .047μf/200v, 5%	320-032
C215	Cap., .015μf/200v, 5%	320-031
C221	Cap., .15μf, 200v, 5%	320-036
C217	Cap., 1000pf/500v, 5%	326-005
C216	Cap., 4700pf/500v, 5%	326-018
R203	Resistor, 1.2K, 1/4W, 5%	595-122
WIDTH SWITCH ASSEMBLY		
S204	Switch, rotary, ceramic	624-007
C228	Cap., 100pf	311-007
C227	Cap., 400pf/500v, 10%	311-026
C226	Cap., 330pf	311-029
C223	Cap., .015μf/200v, 5%	320-031
C222	Cap., .047μf	320-032
C229	Cap., .47μf	320-035
C230	Cap., .15μf	320-036
C225	Cap., 1000pf/500v, 5%	326-005
C224	Cap., 4700pf/500v, 5%	326-018
TIME SWITCH ASSEMBLY		
S205	Switch, Index PA301	624-029
C233	Cap., 150pf	311-008
C234	Cap., 500pf	311-009
C236	Cap., .005μf	311-011
C232	Cap., 33pf	311-024
C235	Cap., .0015μf	311-033
C231	Cap., TE1407, 10μf/100v	316-032
R210	Resistor, 10K, 1/2W, 5%	596-103
R209	Resistor, 18K, 1/2W, 5%	596-183
R208	Resistor, 8.2K, 1W, 5%	597-822
CHOKE ASSEMBLY		
L301	R.F. Choke	10732
L302	Inductor, Fixed	10563
R301	Resistor, 1.8K, 1/2W, 5%	596-182
	Transistor, Socket	490-001
	Mounting Kit	
Q301	Transistor, DTG 2400	663-059
TERMINAL BOARD ASSEMBLY		
	Terminal Board, 10-pt	480-005
CR101-105, 106-113	Diode, 1N4005	376-034
R102, 104, 106-109	Resistor, 1Ω, 5W, WW	610-002

CIRCUIT REFERENCE	DESCRIPTION	E-H PART NO.
R105	Resistor, 5Ω, 3W, WW	610-003
R101, 103	Resistor, 3Ω, 5W, WW	610-023
REAR PANEL ASSEMBLY		
Q101-104	Transistor, 2N1022	663-007
	Heat Sink	490-029
B101	Fan	570-008
J101	Power Receptacle	700-033
	Fuse holder	396-001
	Fan Grill	570-009
J102	Connector, 24-pin	700-022
MISCELLANEOUS		
T102	Balun Assembly	11384
	Knob, Medium	443-008
	Knob, Small	443-009
F101	Fuse, 2 amp, (S.B.), or	398-002
	Fuse, 1.5 amp	398-010
	Core	361-009
	Cover Bottom	11350
	Cover Top	11349
	Rubber Bumper	417-002
	Power Cord	786-001

D-11573 A

REVISIONS

A	INITIAL RELEASE	



PROPRIETARY INFORMATION
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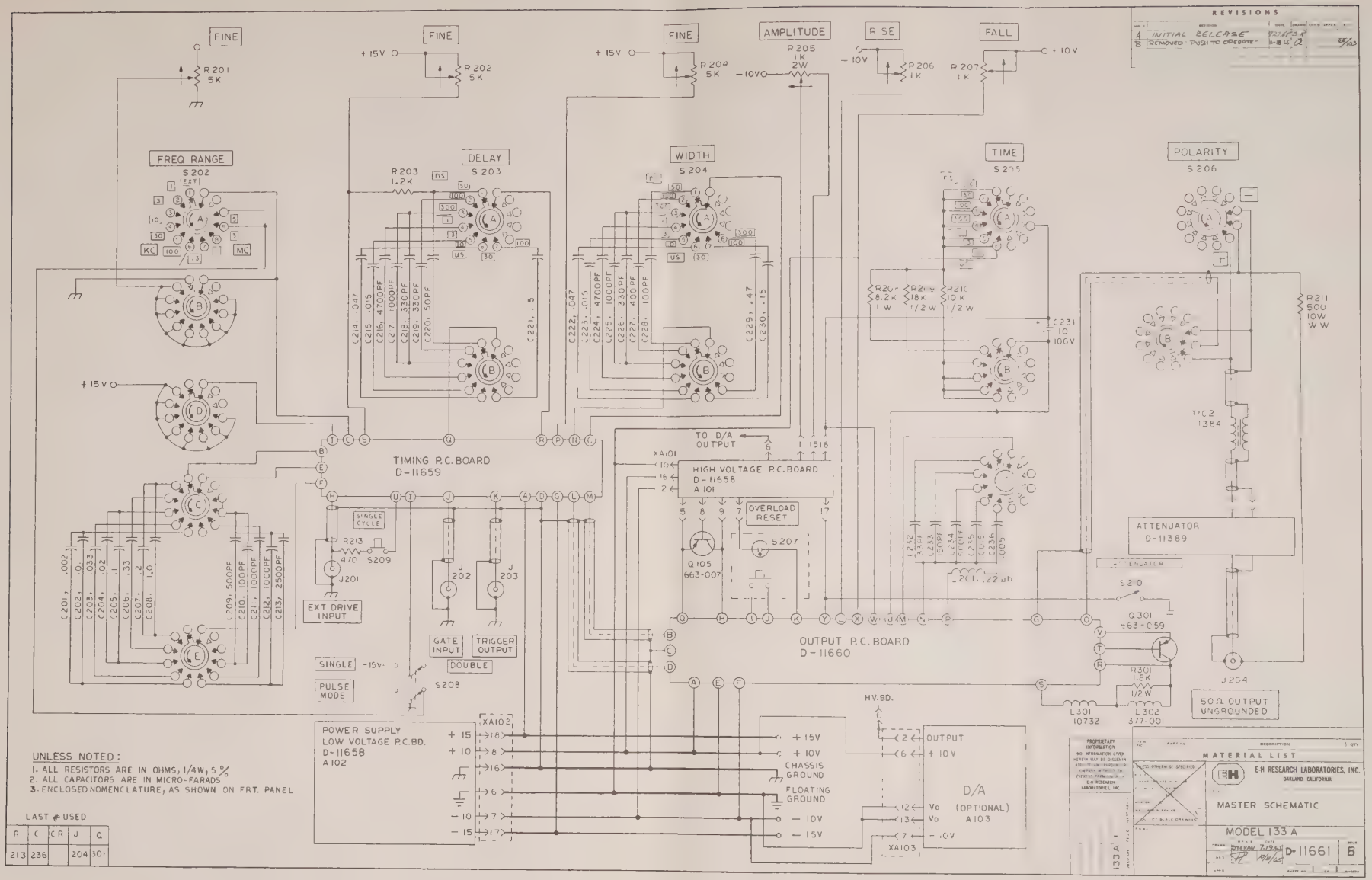
MATERIAL LIST

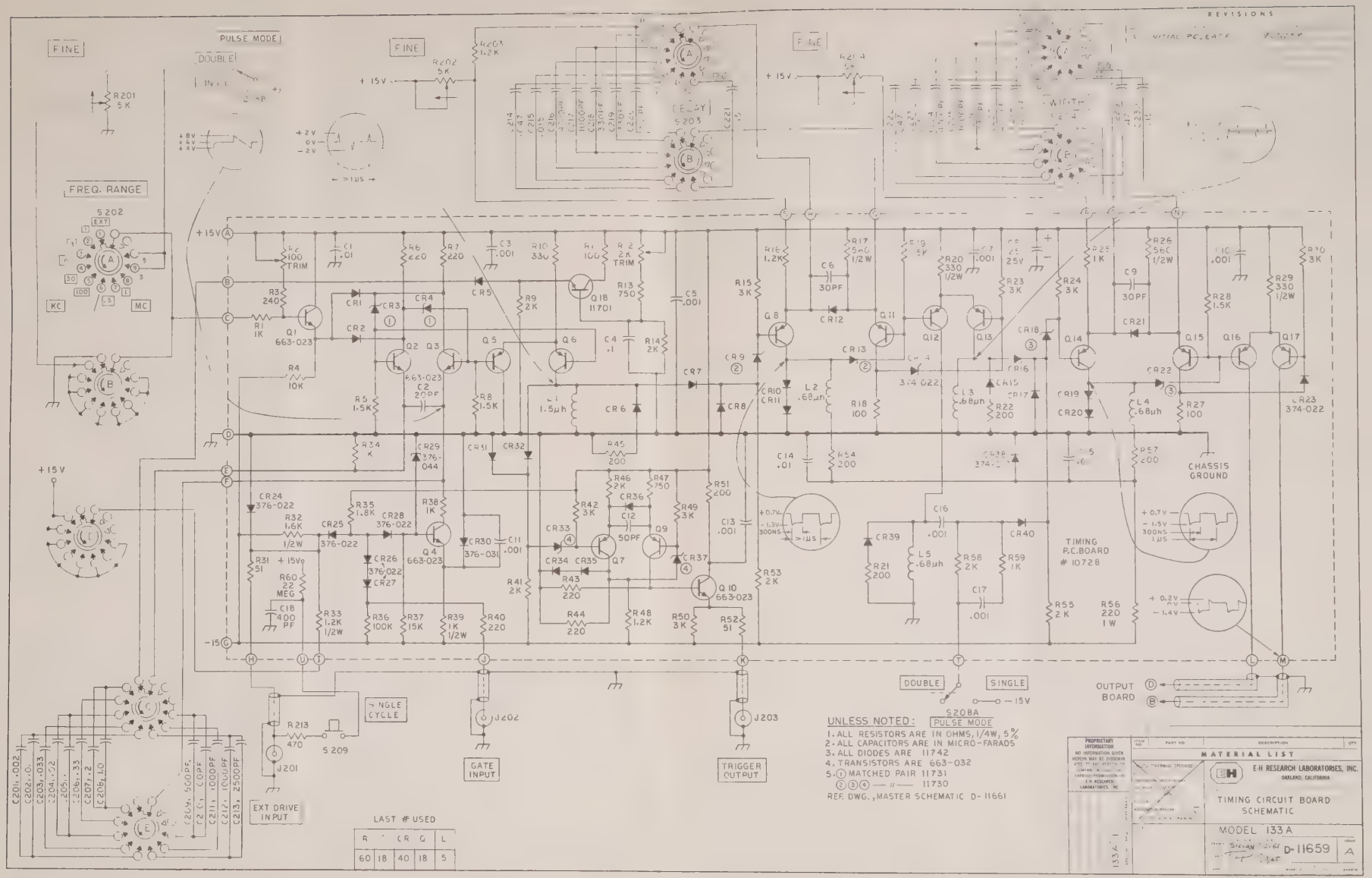
E-H RESEARCH LABORATORIES, INC.
OAKLAND, CALIFORNIA

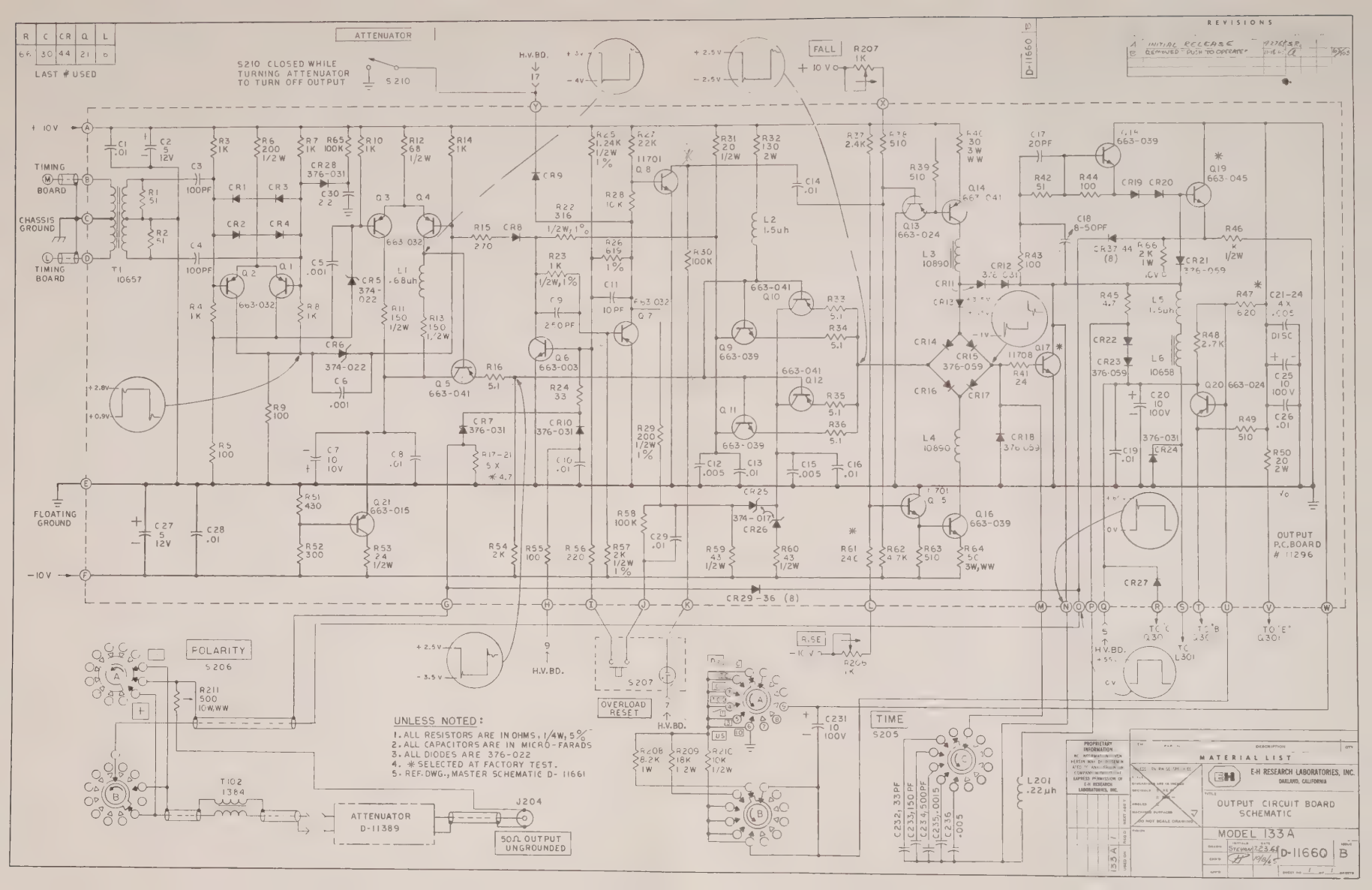
BLOCK DIAGRAM

MODEL 133 A

D-11573 A


REVISIONS
A INITIAL RELEASE
B REMOVED "PUSH TO OPERATE"
FINE
R 201 5K
FINE
+ 15V
R 202 5K
FINE
+ 15V
R 204 5K
AMPLITUDE
R 205 1K 2W
- 10V
R SE
- 10V
R 206 1K
FALL
R 207 1K
+ 10V
FREQ RANGE
S 202
EXT
KC
MC
DELAY
S 203
R 203 1.2K
WIDTH
S 204
TIME
S 205
POLARITY
S 206
R 208 8.2K 1 W
R 209 18K 1/2 W
R 210 10 K 1/2 W
C 231 10 100V
R 211 500 10W WW
T1C2 1384
TIMING P.C. BOARD D-11659
TO D/A OUTPUT
HIGH VOLTAGE P.C. BOARD D-11658 A101
OVERLOAD RESET
S 207
Q 105 663-007
ATTENUATOR D-11389
ATTENUATOR
S 210
Q 301 663-059
R 301 1.8K 1/2W
L 301 10732
L 302 377-001
J 204
50Ω OUTPUT UNGROUNDED
SINGLE CYCLE
R 213 470
S 209
J 201
EXT DRIVE INPUT
J 202
J 203
GATE INPUT
TRIGGER OUTPUT
SINGLE
DOUBLE
PULSE MODE
S 208
OUTPUT P.C. BOARD D-11660
HV. BD.
POWER SUPPLY LOW VOLTAGE P.C. BD. D-11658 A102
XA102
+ 15
+ 10
- 10
- 15
+ 15V
+ 10V
CHASSIS GROUND
FLOATING GROUND
- 10V
- 15V
OUTPUT
+ 10V
D/A (OPTIONAL) A103
-.6V
XA103
UNLESS NOTED:
1. ALL RESISTORS ARE IN OHMS, 1/4W, 5%
2. ALL CAPACITORS ARE IN MICRO-FARADS
3. ENCLOSED NOMENCLATURE, AS SHOWN ON FRT. PANEL
LAST # USED
R 213
C 236
J 204
Q 301
PROPRIETARY INFORMATION
MATERIAL LIST
E-H RESEARCH LABORATORIES, INC. OAKLAND, CALIFORNIA
MASTER SCHEMATIC
MODEL 133 A
D-11661
B
133A

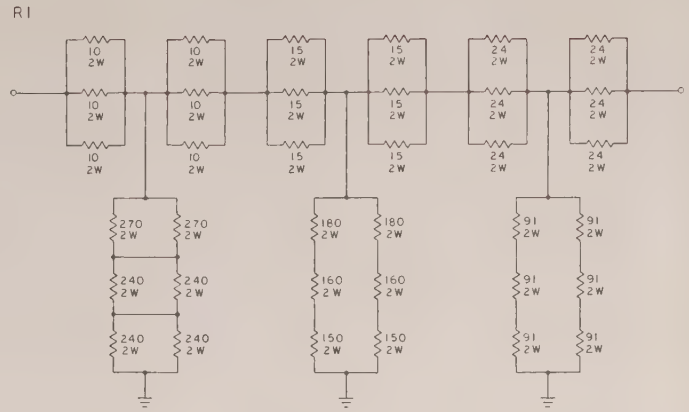

REVISIONS
FINE
PULSE MODE
DOUBLE
SINGLE
R201 5K
R202 5K
R203 1.2K
R214 5K
FREQ. RANGE
S202
S203
+15V
-15V
Q1 663-023
Q2 Q3
Q4 663-023
Q5
Q6
Q7
Q8
Q9
Q10 663-023
Q11
Q12
Q13
Q14
Q15
Q16
Q17
Q18 11701
CR1
CR2
CR3
CR4
CR5
CR6
CR7
CR8
CR9
CR10
CR11
CR12
CR13
CR15
CR16
CR17
CR18
CR19
CR20
CR21
CR22
CR23 374-022
CR24 376-022
CR25 376-022
CR26 376-022
CR27
CR28 376-022
CR29 376-044
CR30 376-031
CR31
CR32
CR33
CR34
CR35
CR36
CR37
CR39
CR40
TIMING P.C.BOARD # 10728
CHASSIS GROUND
OUTPUT BOARD
S208A
J201
J202
J203
EXT DRIVE INPUT
GATE INPUT
TRIGGER OUTPUT
S 209
UNLESS NOTED: PULSE MODE
1. ALL RESISTORS ARE IN OHMS, 1/4W, 5%
2. ALL CAPACITORS ARE IN MICRO-FARADS
3. ALL DIODES ARE 11742
4. TRANSISTORS ARE 663-032
5. (1) MATCHED PAIR 11731
(2)(3)(4) — " — 11730
REF. DWG., MASTER SCHEMATIC D-11661
LAST # USED
A 60
CR 18
Q 40
L 18
5
MATERIAL LIST
E-H RESEARCH LABORATORIES, INC.
OAKLAND, CALIFORNIA
TIMING CIRCUIT BOARD SCHEMATIC
MODEL 133A
D-11659
A

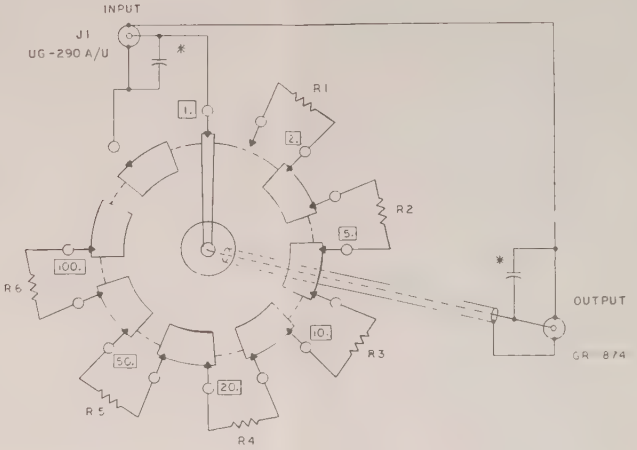

R C CR Q L
66 30 44 21 5
LAST # USED
ATTENUATOR
S210 CLOSED WHILE TURNING ATTENUATOR TO TURN OFF OUTPUT
S 210
H.V.BD.
17
FALL
R207 1K
+ 10 V
D-11660 B
REVISIONS
A INITIAL RELEASE
B REMOVED "PUSH TO OPERATE"
+ 10V
TIMING BOARD
CHASSIS GROUND
FLOATING GROUND
- 10V
T1 10657
663-032
663-041
663-039
663-003
663-024
663-045
374-022
376-031
376-059
374-017
376-039
376-022
OUTPUT P.C.BOARD # 11296
TO "C" Q30
TO "B" Q30
TO "E" Q30
H.V.BD.
9
H.V.BD.
7
H.V.BD.
POLARITY
S 206
S 207
OVERLOAD RESET
R.SE
R205 1K
TIME
S205
R211 500 10W,WW
T102 1384
ATTENUATOR D-11389
J204
50Ω OUTPUT UNGROUNDED
C231 10 100V
L201 .22μh
C232, 33PF
C233, 150 PF
C234, 500PF
C235, .005
C236 .005
UNLESS NOTED:
1. ALL RESISTORS ARE IN OHMS, 1/4W, 5%
2. ALL CAPACITORS ARE IN MICRO-FARADS
3. ALL DIODES ARE 376-022
4. * SELECTED AT FACTORY TEST.
5. REF. DWG., MASTER SCHEMATIC D- 11661
CR29-36 (8)
PROPRIETARY INFORMATION
MATERIAL LIST
E-H RESEARCH LABORATORIES, INC.
OAKLAND, CALIFORNIA
OUTPUT CIRCUIT BOARD SCHEMATIC
MODEL 133A
D-11660 B

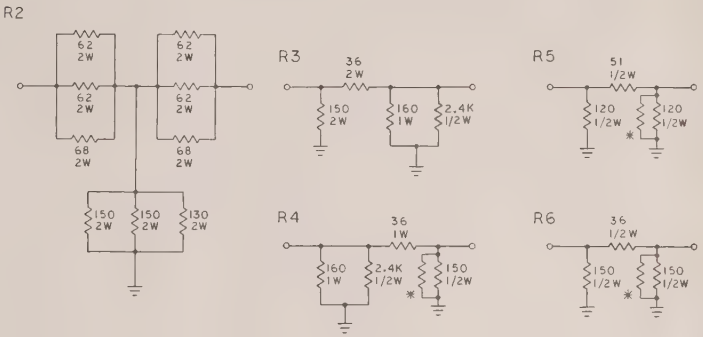
D-11389 A

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED
A	INITIAL RELEASE	9-26-67	PRS.







UNLESS NOTED

1. ALL RESISTORS ARE IN OHMS
2. REF. DRW., MASTER SCHEMATIC
3. FACTORY SELECT *

PROPRIETARY INFORMATION

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MATERIAL LIST

UNLESS OTHERWISE SPECIFIED

E-H RESEARCH LABORATORIES, INC.
OAKLAND, CALIFORNIA

ATTENUATOR 100:1
SCHEMATIC

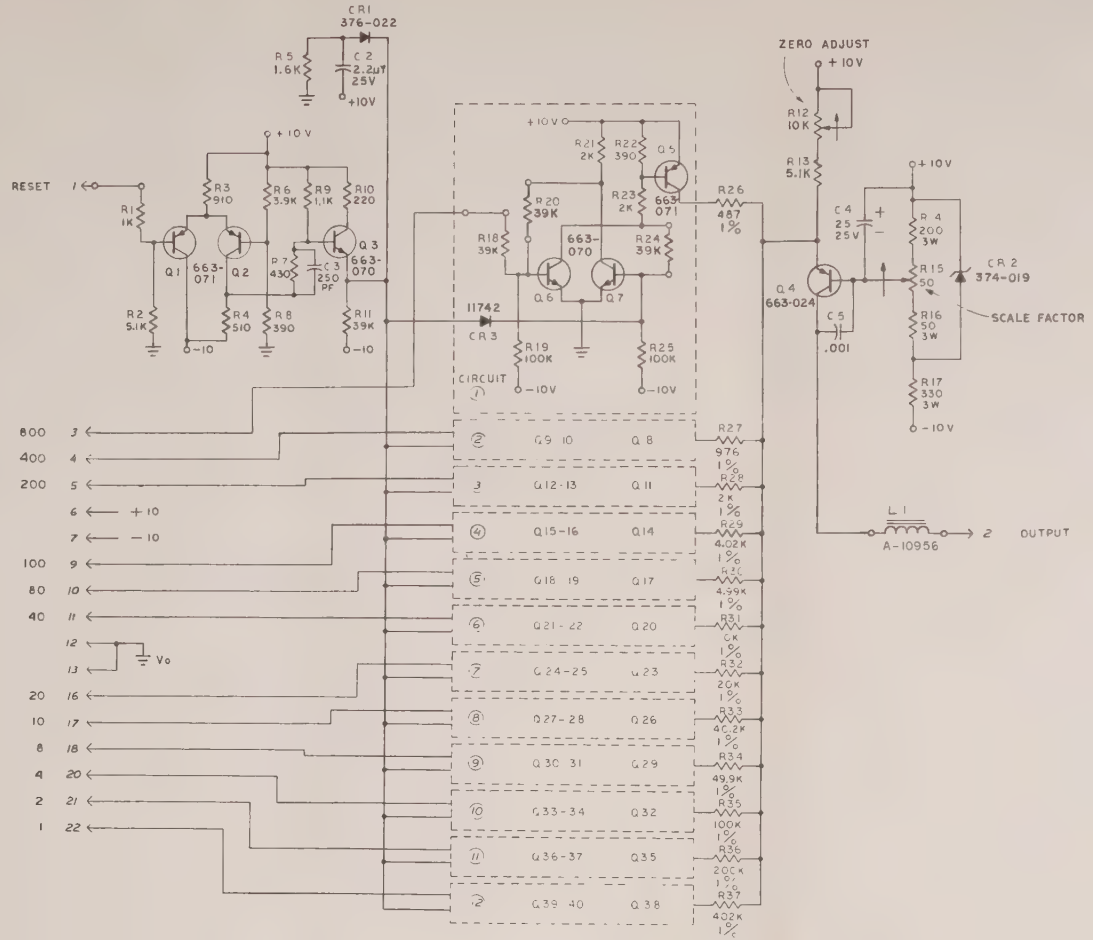
MODEL: STD.

DO NOT SCALE DRAWING

133 A
123 A

D-11389 A

SHEET 1 OF 1



D-11501 C

REVISIONS

A	INITIAL RELEASE	7-7-66	S.E.
B	PILOT RUN EVAL	8-16-66	S.E.
C	C2 WAS CONN. TO -10V	11-9-66	S.E.

UNLESS NOTED:

1. ALL RESISTORS ARE IN OHMS, 1/4W, 5%
2. ALL CAPACITORS ARE IN MICRO-FARADS
3. REF. DWG.,
   D-11855 ASSEMBLY
   B-11294 P.C. BOARD

PROPRIETARY INFORMATION

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UNLESS OTHERWISE SPECIFIED

DO NOT SCALE DRAWING

MATERIAL LIST

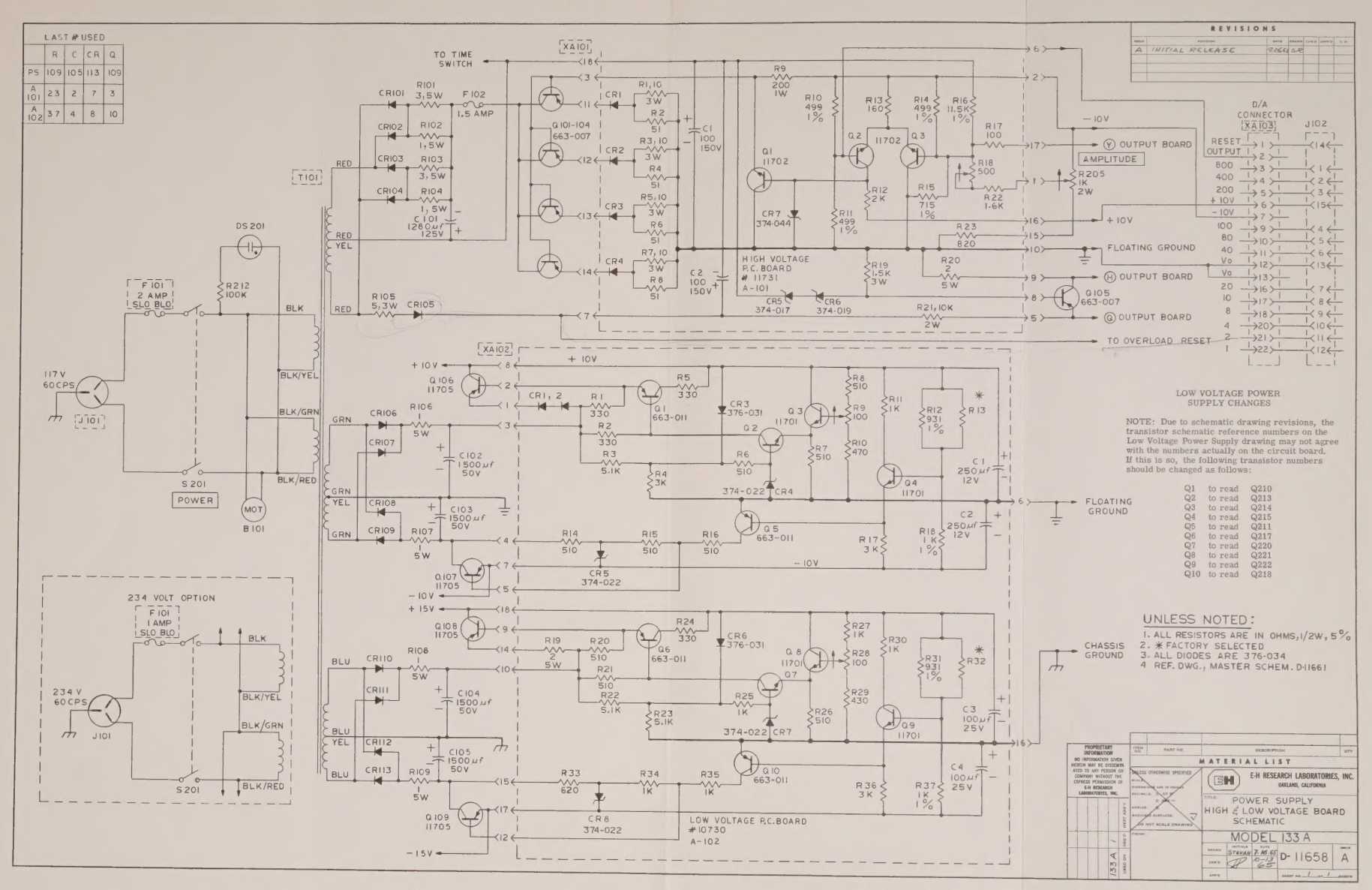
E-H RESEARCH LABORATORIES, INC.
OAKLAND, CALIFORNIA

DIGITAL TO ANALOG CONVERTER + DC LATCH OUTPUT CHOKE

MODEL 930-2

DRAWN	STEVAN	4-6-66	D-11501 C
CHKD	TLM	7-15-66	
APPD		12-15-66	

123A .023 1033 135A 135 2 123 2


LAST # USED
PS 109 105 113 109
A 101 23 2 7 3
A 102 37 4 8 10
REVISIONS
A INITIAL RELEASE 7.26.65 S.R.
TO TIME SWITCH
XA101
XA102
T101
CR101
R101 3.5W
F102 1.5 AMP
CR102
R102 1.5W
CR103
R103 3.5W
CR104
R104 1.5W
C101 1280 µf 125V
RED
RED YEL
RED
R105 5.3W
CR105
DS201
F101 2 AMP SLO BLO
R212 100K
BLK
BLK/YEL
BLK/GRN
BLK/RED
117V 60CPS
J101
S201
POWER
MOT
B101
Q101-104 663-007
CR1
R1,10 3W
R2 51
CR2
R3,10 3W
R4 51
CR3
R5,10 3W
R6 51
CR4
R7,10 3W
R8 51
C1 100 150V
C2 100 150V
HIGH VOLTAGE P.C. BOARD # 11731 A-101
R9 200 1W
R10 499 1%
Q1 11702
CR7 374-044
R11 499 1%
R13 160
R14 499 1%
R16 11.5K 1%
Q2 11702
Q3 11702
R17 100
R18 500
R12 2K
R15 715 1%
R22 1.6K
R205 1K 2W
R23 820
R19 1.5K 3W
R20 2 5W
CR5 374-017
CR6 374-019
Q105 663-007
R21, 10K 2W
-10V
+10V
FLOATING GROUND
Ⓨ OUTPUT BOARD
AMPLITUDE
Ⓗ OUTPUT BOARD
Ⓠ OUTPUT BOARD
TO OVERLOAD RESET
D/A CONNECTOR XA103
J102
RESET OUTPUT
800
400
200
+10V
-10V
100
80
40
Vo
Vo
20
10
8
4
2
1
Q106 11705
CR1, 2
R1 330
R5 330
Q1 663-011
CR3 376-031
Q3 11701
R8 510
R9 100
R11 1K
R12 931 1%
R13
R106 5W
CR106
CR107
C102 1500 µf 50V
R2 330
R3 5.1K
R4 3K
Q2
R6 510
R7 510
R10 470
CR4 374-022
Q4 11701
C1 250 µf 12V
GRN
GRN YEL
GRN
CR108
CR109
C103 1500 µf 50V
R107 5W
Q5 663-011
R14 510
R15 510
R16 510
CR5 374-022
R17 3K
R18 1K 1%
C2 250 µf 12V
Q107 11705
FLOATING GROUND
Q108 11705
R24 330
Q6 663-011
CR6 376-031
Q8 11701
R27 1K
R28 100
R30 1K
R31 931 1%
R32
R19 2 5W
R20 510
R21 510
R22 5.1K
Q7
R25 1K
R26 510
R29 430
Q9 11701
C3 100 µf 25V
BLU
BLU YEL
BLU
CR110
CR111
CR112
CR113
R108 5W
R109 5W
C104 1500 µf 50V
C105 1500 µf 50V
R23 5.1K
374-022 CR7
Q10 663-011
R33 620
R34 1K
R35 1K
R36 3K
R37 1K 1%
C4 100 µf 25V
CR8 374-022
Q109 11705
LOW VOLTAGE P.C. BOARD # 10730 A-102
-15V
CHASSIS GROUND
234 VOLT OPTION
F101 1 AMP SLO BLO
234 V 60CPS
J101
S201
LOW VOLTAGE POWER SUPPLY CHANGES
NOTE: Due to schematic drawing revisions, the transistor schematic reference numbers on the Low Voltage Power Supply drawing may not agree with the numbers actually on the circuit board. If this is so, the following transistor numbers should be changed as follows:
Q1 to read Q210
Q2 to read Q213
Q3 to read Q214
Q4 to read Q215
Q5 to read Q211
Q6 to read Q217
Q7 to read Q220
Q8 to read Q221
Q9 to read Q222
Q10 to read Q218
UNLESS NOTED:
1. ALL RESISTORS ARE IN OHMS, 1/2W, 5%
2. * FACTORY SELECTED
3. ALL DIODES ARE 376-034
4 REF. DWG., MASTER SCHEM. D-11661
PROPRIETARY INFORMATION
MATERIAL LIST
E-H RESEARCH LABORATORIES, INC.
OAKLAND, CALIFORNIA
POWER SUPPLY HIGH & LOW VOLTAGE BOARD SCHEMATIC
MODEL 133 A
D- 11658 A

MP MASTER
MA33508